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Assessment of the Okak Unit Arctic Charr Population in 1987

by

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Abstract

Reported landings of Arctic charr from the Okak assessment unit totaled 20 t in 1987, a decrease of 32% from 1986 and represented only 46% of the TAC. This catch represented 20% of the total catch of Arctic charr from the Nain Region in 1987. Effort decreased by 22% from 1986. Likelihood ratio statistics were used to examine temporal and spatial variation in the size composition of the catches from 1980 to 1987. Significant differences were found among years, inshore and offshore fishing zones, and specific time periods within the fishing season. However, there have been no consistent trends in the mean length or age of catches over the time period. The 1977-79 year-classes represented 72% of the catch in 1987. A sequential population analysis was carried out on catch-at-age data from 1977 to 1987 and suggested a reduction in the 1986 TAC of 43 t to a reference level catch in 1988 of 27 to 36 t.

RESUME

Les débarquements d'omble chevalier enregistrés pour l'unité d'évaluation de l'Okak ont totalisé 20 t en 1987, ce qui représente une baisse de 32 % par rapport à 1986, et constitue seulement 46 % du TPA. Ces prises représentaient 20 % du total des captures d'omble chevalier de la région de la Nain en 1987. L'effort a diminué de 22 % par rapport à 1986. Les statistiques sur les rapport de vraisemblance ont servi à examiner la variation temporelle et spatiale dans la composition par taille des captures de 1980 à 1987. Des différences significatives ont été observées d'une année à l'autre, entre les zones de pêche côtières et hauturières, et entre des périodes données dans la saison de pêche. Cependant, on n'a relevé aucune tendance constante dans la longueur moyenne ou l'âge des captures pendant cette période. Les classes annuelles de 1977-1979 représentaient 72 % des prises en 1987. Une analyse séquentielle de population portant sur les données concernant l'âge à la capture entre 1977 et 1987 indique qu'il faudrait réduire le TPA, fixé à 43 t en 1986, à un niveau de référence de 27 à 36 t pour 1988.

Introduction

Catch statistics from the Okak assessment unit, made up of the Okak Bay and Cutthroat subareas (Fig. 1), have been available since 1974. It was first assessed as a single unit in 1985. Annual landings have ranged from a low of 5 t in 1975 to 76 t in 1978 with an average of 37 t over the 14-year period. From 1977 to 1987 landings from this unit have represented 25% of the total commercial production from the Nain Fishing Region. In 1987, 20% of the commercial landings came from the Okak unit. The recommended total allowable catch (TAC) in 1987 was 43 t. This was partially divided into a specific inshore quota of 25.2 t for the Okak Bay subarea.

This paper summarizes the results of the 1987 fishery and provides a forecast of available harvest, or reference level catch, for 1988.

Assessment

Catch and effort data

Catch and effort data for the Okak assessment unit are summarized in Table 1 for 1974-87. Landings in 1987 totaled 20 t, a decrease of 32% from 1986, and represented only 46% of the TAC. Eighty percent of the catch was taken in the Okak Bay subarea which was 62% of the quota applied to Okak Bay. The remainder of the catch was taken in the offshore Cutthroat area. Effort decreased by 22% while catch per unit effort was 13% lower than the previous year which contributed to the decline in landings from the Okak unit in 1987.

Size distribution of commercial landings

Since 1980, approximately 34,000 fish have been sampled from the Okak assessment unit to obtain information on the size distribution of the commercial landings. The length-frequency data were examined to determine any heterogeneity of samples which could be related to the effect of commercial exploitation on the stock. Likelihood ratio statistics were used to examine temporal variation in the size distributions.

Arctic charr were measured for fork length and recorded in two-centimeter intervals. The smallest fish measured over the past eight years (1980-87) were in the 34 cm interval (34.0-35.9 cm), while the largest were from the 76 cm grouping. Analyses, however, were conducted on truncated data which excluded fish less than 42 cm in size and those fish which were in size categories 66 cm or higher. In total, 99.1% of all fish measured were within the 42-64 cm length intervals. The truncation also removed the possibility of obtaining any zero values for expected cell counts in the analyses.

There was a highly significant difference in the size distribution of catches among years ($G = 1484$, $df = 77$, $P = 0.000$, $N = 34,152$). The modal size has changed from the 50 cm interval in 1980-83 to the 48 cm interval during the past four years. Mean lengths are also summarized in Table 2. Significant differences also exist in the size distribution of the catches between the

inshore and offshore zones of the Okak unit (G = 819, df = 11, P = 0.000, N = 34,152). Within the two zones there are differences among years (Table 3). Similar to the analyses for the Nain and Voisey unit catches (Dempson 1988a, 1988b), the fishing season was stratified into four time periods: June 15-July 14, July 15-July 31, August 1-15, and August 16 to the end of the fishing season. There is a difference in the size distribution among time period, and within individual time periods the size distribution differs between years (Table 3). There is a tendency for mean length of catches to decrease as the fishing season progresses for this assessment unit also (Table 4). Fish in the offshore zone are somewhat larger than the fish caught in the inshore zone (Table 2).

Cohort analyses

Numbers at age were available since 1977 and are summarized in Table 5. Data were derived from annual commercial sampling programs. Mean age of the catch has ranged from 9.1 to 12.1 years with no apparent increasing or decreasing trend. On average, 59% of the catch is made up of three age-classes of fish represented by 8-, 9-, and 10-year-olds. The 1977-79 year-classes made up 72% of the catch in 1987.

Weights at age were calculated from commercial samples obtained from 1977 to 1987. Gutted head-on weights were converted to whole weights using the conversion factor 1.22 (Dempson 1984). For yield-per-recruit analysis, mean weight at age for the period 1977-79 was used as in past assessments. For stock projections, mean weight at age for the period 1984-87 was used (Table 6).

Total mortality ($\bar{Z}$) was calculated using the Paloheimo method (Ricker 1975) and the average value for all years (1977-78 to 1986-87) was 0.66. The average $\bar{Z}$ for the last three years was also 0.66. Assuming a natural mortality rate of 0.2 results in an estimate of fishing mortality of about 0.46. An estimate of total mortality derived from a catch curve using catch per unit effort at age data from 1985 to 1987 (ages 10-16) similarly gave a value of $\bar{Z}$ of 0.66. No estimate of mortality was available from tag recapture information in 1987.

An initial cohort analysis was run using partial recruitment values and terminal fishing mortality (F_T = 0.35) from last year's assessment (Dempson and LeDrew 1987). An iterative procedure was used to obtain estimates of fishing mortality for the oldest age group (F_B) (Rivard 1982). Following this, partial recruitment rates were calculated using the historical averaging method from the matrix of fishing mortality values from 1981 to 1985. These values were then applied to the initial terminal fishing mortality rate and the procedure repeated until the partial recruitment values stabilized (Table 6).

Yield per recruit was calculated by the method of Thompson and Bell (Ricker 1975) using partial recruitment rates and mean weight at age. $F_{0.1}$ was 0.41 at a yield per recruit of 0.75 kg. This $F_{0.1}$ value was rounded to 0.4 for conformity with other assessment units.

Cohort analyses were run using a range of terminal fishing mortality rates from 0.15 to 0.5. In each run, fishing mortality rates for the oldest age group (F_B) were re-evaluated using the iterative procedure. Regressions of F (weighted mean F for fully-recruited fish) on fishing effort and mean mid-year population biomass on catch per unit effort of fully-recruited fish were used in tuning the analysis to determine an appropriate value for F_T in 1987. Data from 1977 to 1987 (excluding 1984 as in past assessments) were used in the regression analyses. Regressions were also run with the 1979 data excluded which gave a somewhat better relationship.

Regressions of F on effort showed a decrease in the correlation coefficient with an increase in F_T (Table 7). These regressions were not statistically significant beyond $F_T = 0.35$. The distance of the last point (1987) to the regression line was lowest when $F_T = 0.45$, while the intercept value was the lowest when $F_T = 0.25$. The sum of the residuals or the sum of squares of the residuals for the last three years (1985-87) increased with F_T. Regressions with only 1984 data excluded yielded similar results, although the intercept value was lowest when when $F_T = 0.2$.

Regressions of average population biomass on catch per unit of effort had the best correlation when $F_T = 0.3$. The distance of the last point (1987) to the regression line was also smallest when $F_T = 0.3$ as was the smallest intercept. The sum of the residuals for the past three years was lowest when $F_T = 0.2$ while the sum of the squares of the residuals for the past three years was lowest when terminal F was 0.3 (Table 7). Regressions with only 1984 data excluded followed similar trends, although the best correlation and lowest residuals were obtained at slightly lower values of terminal fishing mortality.

In summary, regression analyses suggested a value of F_T from 0.25 to 0.35. Estimates derived from the Paloheimo method and catch curves suggest a value of about 0.45.

Catch projections

Projections were run with F_T varying from 0.25 to 0.35. Recruitment for the projections was estimated from the geometric mean of population numbers for age 6- and 7-year-old fish for the years 1977-85. Weights at age were based on 1984-87 data. Table 8 summarizes the population numbers and fishing mortality rates for the cohort analysis run with $F_T = 0.3$.

Results of the projections are summarized in Table 9. The reference level catch in 1988 ranges from 27 to 36 t with the highest value occurring when $F_T = 0.25$. These values represent a reduction in the 43 t TAC recommended for 1987. In view of the decreased catch per unit effort in the Okak unit during the past several years, it may be warranted to reduce the reference level catch on the basis of the information derived from the 1987 data. With terminal F estimated to be 0.3 in 1987, the reference level catch for the Okak assessment

unit in 1988 would be 30.6 t. This could be divided into a specific inshore quota of 22 t based on the average proportion of inshore to offshore catches during the past five years (72%).

References

Dempson, J. B. 1984. Conversion factors for northern Labrador Arctic charr landings statistics. CAFSAC Res. Doc. 84/6. 8 p.

1988a. Assessment of the Nain unit Arctic charr population in 1987. CAFSAC Res. Doc. 88/6. 21 p.

1988b. Assessment of the Voisey unit Arctic charr population in 1987. CAFSAC Res. Doc. 88/7. 15 p.

Dempson, J. B., and L. J. LeDrew. 1987. Analysis of the Okak assessment unit Arctic charr populations in 1986. CAFSAC Res. Doc. 87/17. 12 p.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191.

Rivard, D. 1982. APL programs for stock assessment (revised). Can. Tech. Rep. Fish. Aquat. Sci. 1091.

Table 1. Summary of catch and effort statistics for the Okak assessment unit, 1974-87. Quotas and landings are in kg-round weight, effort is expressed as man-weeks fished.

Year	Quota	Quota area catch	Landings	Effort	CUE
1974			46,891		
1975			5,057		
1976			25,338	148	171
1977			42,392	243	174
1978			76,024	352	216
1979			43,261	283	153
1980			49,035	253	194
1981	27,300	11,049	47,541	202	235
1982	27,300	9,031	34,171	186	184
1983	21,000	30,732	48,978	286	171
1984	27,000	13,864	18,146	94	193
1985	27,000	24,746	33,261	208	160
1986	42,000		28,896	172	168
1987	43,000		19,649	134	147

Table 2. Length-frequency distributions of Okak assessment unit catches from 1980 to 1987. Mean lengths are also shown for the total unit and for inshore and offshore zones.

Fork length interval (cm)	Years								
	1980	1981	1982	1983	1984	1985	1986	1987	Total
42	187	59	49	69	61	45	201	131	802
44	482	132	186	423	310	245	537	469	2,784
46	870	219	313	961	529	583	883	738	5,096
48	1,076	216	444	1,499	511	728	965	851	6,290
50	1,214	272	462	1,741	437	703	819	751	6,399
52	1,013	214	353	1,372	286	513	563	494	4,808
54	811	182	258	970	164	360	373	311	3,429
56	512	121	151	562	93	252	216	175	2,082
58	309	80	87	360	51	140	116	90	1,233
60	193	49	50	205	20	71	61	38	687
62	93	34	24	116	14	35	25	12	353
64	38	20	21	51	6	29	16	8	189
Total	6,798	1,598	2,398	8,329	2,482	3,704	4,775	4,068	34,152
Mean length total	51.6	51.7	51.3	51.9	49.9	51.3	50.1	50.0	51.1
Inshore	50.9	51.1	50.9	51.5	49.2	50.9	49.7	49.9	50.6
Offshore	52.5	52.6	51.6	52.3	51.4	52.0	50.7	50.6	51.9

Table 3. Summary of likelihood ratio statistics comparing size distribution of commercial Arctic charr catches from the Okak assessment unit, 1980-87. Time periods 1-4 are defined in the text.

Comparison	G	df	P	N
Years	1,484	77	0.000	34,152
Zones	819	11	0.000	34,152
Zones:				
Period 2	41	11	0.000	7,059
Period 3	294	11	0.000	15,510
Period 4	215	11	0.000	11,156
Years:				
Inshore zone	985	77	0.000	20,920
Offshore zone	460	77	0.000	13,232
Period 2	461	77	0.000	7,059
Period 3	700	66	0.000	15,510
Period 4	567	77	0.000	11,156
Time period	1,340	33	0.000	34,152
Time period:				
Inshore zone	811	33	0.000	20,920
Offshore zone	264	33	0.000	13,232

Table 4. Summary of mean length of Arctic charr catches by time period for inshore and offshore fishing zones of the Okak assessment unit.

Time period	Fork length (cm)		
	Inshore zone	Offshore zone	Total
1 - Jun 15-Jul 14	53.5	53.8	53.8
2 - Jul 15-Jul 31	52.1	52.5	52.3
3 - Aug 1-Aug 15	50.7	51.8	51.2
4 - Aug 16-end	49.9	51.2	50.1

Table 5. Estimated catch at age for Arctic charr from the Okak assessment unit, 1977-87.

CATCH AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	84	205	1	130	39	93	475	251	17	41	42
7	139	2465	1989	638	526	713	1762	1371	2675	2056	1008
8	417	8163	7462	5631	2135	2760	4471	2336	4948	6333	1636
9	1084	5494	4997	9175	7166	4167	5787	2151	5385	5197	3686
10	2667	5594	3299	6487	7615	3848	5601	1850	2740	3291	3247
11	3388	3747	1954	2863	4673	3622	5169	2211	2936	1261	1371
12	5417	3953	878	1382	1330	1542	4075	1472	987	875	395
13	2278	2773	761	407	1044	444	1643	1180	740	562	299
14	1694	514	527	350	459	342	658	587	768	148	166
15	1472	1027	410	262	359	183	307	219	103	170	85
16	832	308	351	90	44	57	107	127	75	8	34
17	139	411	234	129	145	38	11	12	50	1	1
18	139	103	95	33	48	15	43	1	6	72	1
19	139	117	130	61	132	1	63	35	56	1	1
6+	19889	34874	23096	27638	25715	17825	30172	13803	21486	20016	11972
7+	19805	34669	23095	27508	25676	17732	29697	13552	21469	19975	11930
8+	19666	32204	21106	26870	25150	17019	27935	12181	18794	17919	10922
9+	19249	24041	13644	21239	23015	14259	23464	9845	13846	11586	9286
10+	18165	18547	8647	12064	15849	10092	17677	7694	8461	6389	5600
11+	15498	12953	5348	5577	8234	6244	12076	5844	5721	3098	2353

Table 6. Summary of weight (kg round) at age data, partial recruitment rates, and calculated $F_{0.1}$ for the Arctic charr population of the Okak assessment unit.

Age	Weight 1977-79	Weight 1984-87	Partial recruitment
6	1.21	1.13	0.006
7	1.48	1.29	0.084
8	1.66	1.59	0.302
9	1.85	1.83	0.630
10	1.98	1.96	1.0
11	2.02	1.88	1.0
12	2.36	2.05	1.0
13	2.30	1.96	1.0
14	2.38	2.02	1.0
15	2.48	1.96	1.0
16	2.30	2.24	1.0
17	2.30	1.83	1.0
18	2.30	2.36	1.0
19	2.30	2.36	1.0

$F_{0.1}$ = 0.43 at a Y/R of 0.74 kg.

Table 7. Results of regressions (1977-87, excluding 1979 and 1984, Part A, and excluding 1984 only, Part B) of F on effort and average population biomass on catch per unit effort (CUE) for various terminal fishing mortality rates (F_T) for the Okak assessment unit.

Regression	Parameter	Terminal F 0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
Part A									
F (weighted mean for fully-recruited fish) on effort	r	0.91	0.88	0.82	0.75	0.68	0.59	0.48	0.42
	intercept	-0.13	-0.05	0.03	0.10	0.17	0.23	0.29	0.35
	residual - 1987	-0.07	-0.06	-0.06	-0.05	-0.03	-0.02	-0.00	0.02
	$\sum$ residuals (1985-87)	-0.03	0.05	0.12	0.18	0.23	0.28	0.32	0.36
	$\sum$ (residuals)^2 (1985-87)	0.01	0.02	0.03	0.04	0.04	0.05	0.06	0.06
Average population biomass (fully-recruited fish) on CUE	r	0.67	0.86	0.89	0.89	0.89	0.89	0.88	0.88
	intercept (t)	31	15	6	0	-5	-8	-11	-13
	residual - 1987 (t)	21	10	3	-2	-5	-7	-9	-11
	$\sum$ residuals (t) (1985-87)	5.3	-4	-10	-14	-17	-19	-20	-21
	$\sum$ (residuals)^2 (t) (1985-87)	608	201	92	77	93	121	151	181
Part B									
F on effort	r	0.83	0.77	0.70	0.62	0.53	0.44	0.35	0.26
	intercept	-0.08	0.00	0.08	0.15	0.22	0.28	0.35	0.40
	residual - 1987	-0.07	-0.07	-0.06	-0.06	-0.04	-0.03	-0.01	0.01
	$\sum$ residuals (1985-87)	-0.02	0.06	0.13	0.19	0.24	0.29	0.34	0.37
Average population biomass on CUE	r	0.69	0.83	0.85	0.84	0.83	0.82	0.81	0.80
	intercept (t)	31	20	13	8	5	3	1	-1
	residual - 1987 (t)	21	8	0	-5	-9	-11	-14	-15
	$\sum$ residuals (t) (1985-87)	4	-10	-19	-25	-30	-33	-35	-37

Table 8. Summary of the population numbers and fishing mortality matrix for the cohort analysis run with F_T = 0.30 on the catch at age data for the Okak assessment unit Arctic charr population.

POPULATION NUMBERS

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	90456	63325	42815	38775	28791	41057	51608	57225	33705	55040	23192
7	57909	73983	51661	35053	31629	23537	33531	41624	46624	27580	45026
8	27531	47286	58342	40496	28122	25419	18625	25858	33002	35752	20721
9	20812	22163	31328	41014	28061	21092	18314	11204	19057	22542	23541
10	12439	16059	13175	21128	25278	16490	13498	9758	7226	10730	13754
11	12503	7771	8086	7801	11428	13805	10019	5984	6315	3437	5807
12	11713	7171	2972	4852	3797	5128	8025	3526	2898	2514	1673
13	4735	4688	2294	1639	2722	1905	2804	2083	1555	1480	1267
14	4219	1815	1329	1190	974	1284	1158	809	1293	603	703
15	2911	1922	1021	611	657	382	742	353	131	364	360
16	1794	1051	644	465	264	213	147	330	91	14	144
17	609	716	582	210	299	176	123	24	155	6	4
18	339	373	214	265	55	114	110	91	8	82	4
19	195	152	212	90	187	2	80	51	74	1	2
6+1	248165	248475	214675	193589	162262	150605	158784	159917	152135	160147	136198

FISHING MORTALITY

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	0.001	0.004	0.000	0.004	0.001	0.003	0.010	0.005	0.001	0.001	0.002
7	0.003	0.038	0.043	0.020	0.019	0.034	0.060	0.037	0.066	0.086	0.025
8	0.017	0.212	0.152	0.167	0.088	0.128	0.308	0.105	0.181	0.218	0.091
9	0.059	0.320	0.194	0.284	0.332	0.246	0.430	0.238	0.374	0.294	0.189
10	0.270	0.486	0.324	0.414	0.405	0.298	0.614	0.235	0.543	0.414	0.300
11	0.356	0.761	0.311	0.520	0.601	0.342	0.844	0.525	0.721	0.520	0.300
12	0.716	0.940	0.395	0.378	0.490	0.404	0.824	0.619	0.472	0.486	0.300
13	0.759	1.060	0.457	0.321	0.551	0.298	1.043	0.602	0.747	0.544	0.300
14	0.586	0.375	0.577	0.393	0.736	0.349	0.989	1.621	1.068	0.316	0.300
15	0.819	0.893	0.587	0.642	0.925	0.755	0.611	1.159	2.035	0.727	0.300
16	0.718	0.391	0.922	0.241	0.204	0.350	1.633	0.555	2.469	0.997	0.300
17	0.290	1.006	0.588	1.138	0.767	0.273	0.104	0.831	0.441	0.194	0.300
18	0.604	0.361	0.673	0.148	3.336	0.157	0.568	0.012	1.564	3.691	0.300
19	0.492	0.673	0.371	0.427	0.481	0.332	0.758	0.441	0.639	0.457	0.300
10+1	0.513	0.700	0.378	0.430	0.489	0.333	0.770	0.475	0.659	0.469	0.300

Table 9. Summary of projected reference level catch (t) for 1988 and 1989 with F_T in 1987 varying from 0.25 to 0.35 for the Okak assessment unit.

	F_T in 1987		
	0.25	0.30	0.35
1988	36.1	30.6	26.6
1989	35.3	31.1	28.1

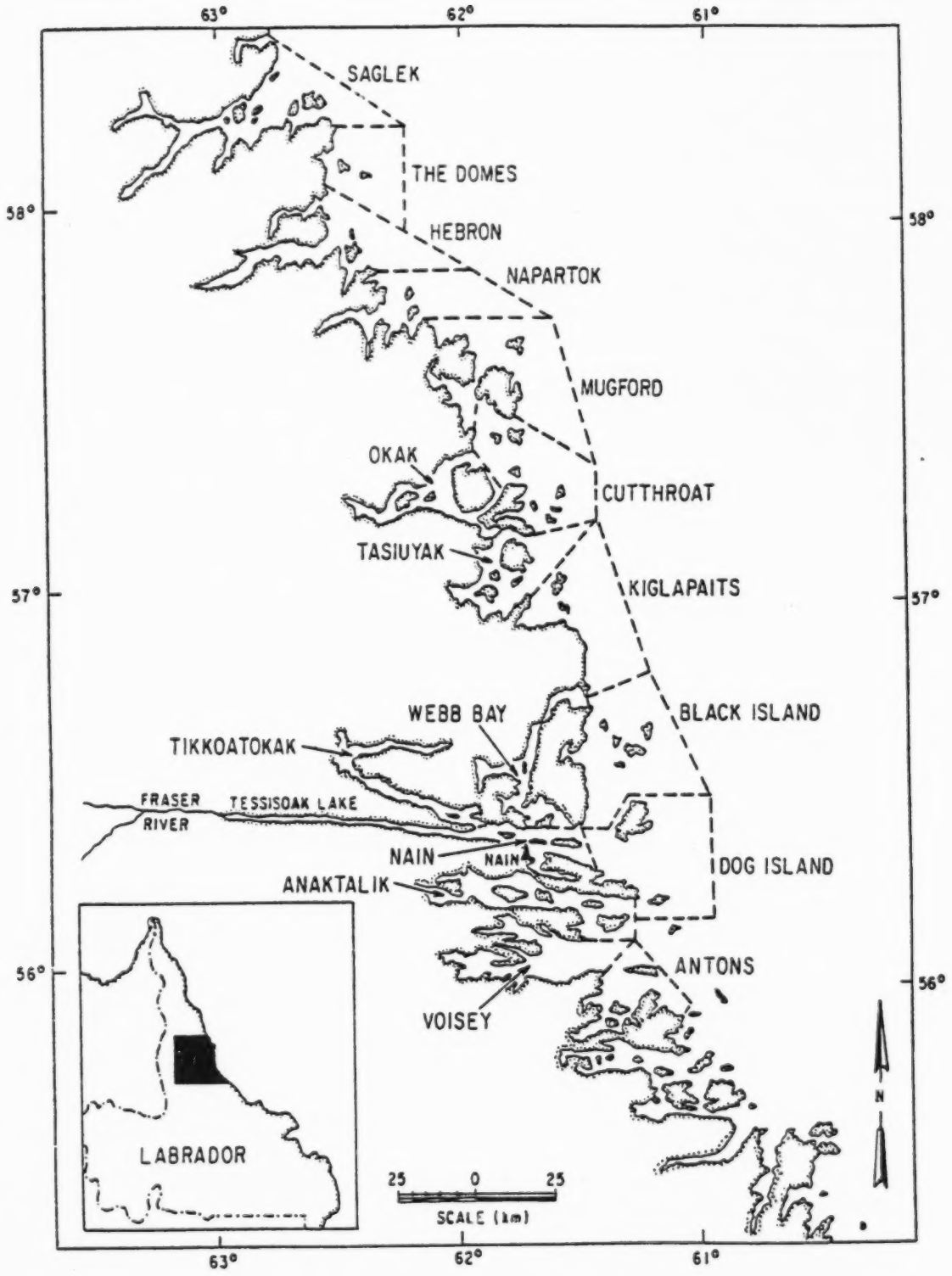

Fig. 1. Geographic separation of the Nain Fishing Region subareas.